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The development and application of autonomous, low-cost, 3D printers

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Design of Low-Cost Autonomous 3D Printer Vending Machines

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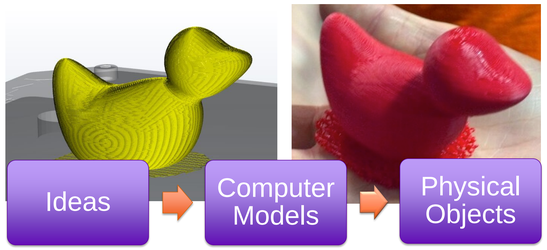
Motivation and Introduction to 3D Printing



Rapid prototyping technology is currently staged to disrupt conventional manufacturing by allowing on-demand, one-off production of parts without the extensive setup required by traditional manufacturing methods. 3D printers, for instance, can automatically fuse or deposit a material (e.g. plastic, metal) to form complete products based on computer aided drawing (CAD) models.

Over the past decade, 3D printers have become increasingly versatile, available, and cost effective. 3D printer kits have become affordable for personal use. Individuals can now assemble desktop-sized machines, download or create CAD models, and print plastic parts (anything from custom prosthetics to replacement cell phone parts) at home. To unlock the full potential of this technology, however, 3D printers must become more accessible, user-friendly, and automated in order to reach a critical mass of users.

Project Scope: Autonomous 3D Printing

- **Resource Procurement**
  - Printer Selection and Fabrication
- **Verification**
  - Benchmark Testing
- **Design**
  - Enclosure Design
  - Hardware & Software Development
- **Deployment**
  - Patent, Production and Mass Distribution Research
  - On-Campus Implementation

- Develop an autonomous 3D printing Vending Machine
- Implement automatic printing request processes and queuing
- Increase accessibility and ease of use of this emerging technology
- Deploy vending machines in academic institutions and public settings

Fused Deposition Additive Manufacturing

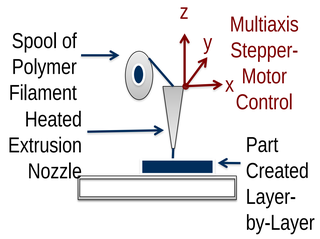


Figure 1. Fused Deposition Modeling

3D prints for K-12 Education

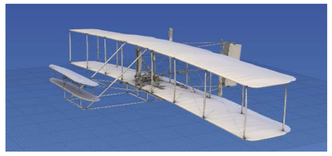


Figure 2. Smithsonian model of Wright Brothers' Plane

- The Smithsonian Museum of American History is cataloging iconic pieces of history using 3D scanning methods.
- The print ready files are posted on the Smithsonian's website.
- The Creative Inquiry team plans to print the Wright Brothers' plane or a similar artifact in the digital library and provide it to a local grade school to be used in discussion.

Vending Machine Design and Development

- Various Printer designs were examined and assessed for their viability as the base printer for the vending machine concept
- Three printers were acquired and assessed.
  - Rapman 3.2, BitsFromBytes
  - RepRap Prusa Mendel i2
  - Makerbot Replicator 5th Generation
- The RepRap 3.2 was selected because it is an open source design, which allows for the printer to be modified and integrated into the automated vending machine. The design of this vending machine, in turn, can then be distributed under an open-license for mass-production and installation in schools and public settings.

Enclosure Design

An enclosure was designed for protection and security in a vending machine application. Design features of the enclosure include:

- Providing users with a simple interface to print and access parts.
- Supporting hardware to allow wireless printing or printing files from a user SD card
- Secure collection area for prints, accessible with the user's ID card
- Plexiglas encasing of the printer itself to allow viewing of the printing process.
- Access panels for maintenance
- The concept for this idea is seen in FIGURE 3

Vending Machine Design and Development

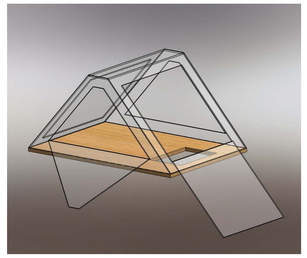


Figure 3. Printer Enclosure Design

Dispensing Mechanism

- In order to provide full automation, an ejector/retrieval mechanism is necessary (FIGURE 4)
- A tensioned belt will be fastened over the heated print bed
- The bed will be tensioned on top of two rollers connected by a belt-drive system.
- The belt remains tensioned and stationary during printing
- Once the print is finished, the belt will lose tension and a stepper motor will rotate the rollers, moving the belt around the bed.
- As the printed part approaches the edge of the bed, it will peel off and eject into a secure collection area.

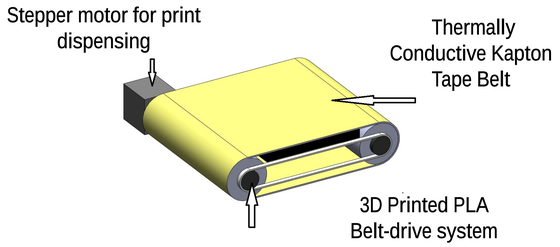
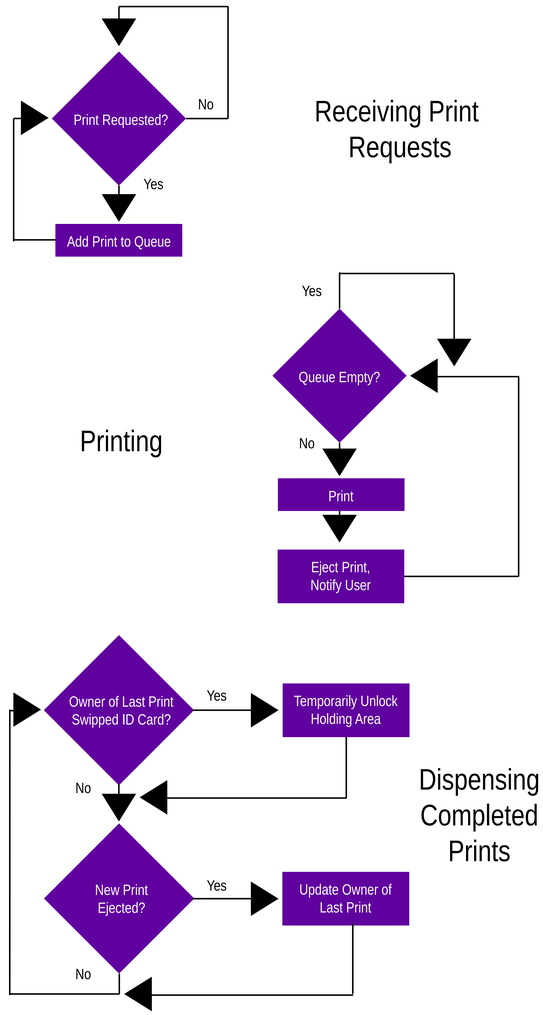


Figure 4. Dispensing Design Concept

ASEE-SE Conference

- The team presented their design progress at the American Society of Engineering Education – Southeast Conference, Macon GA, 2014.

Software Automation Flow Chart



Conclusions

- The objective is to develop a low-cost autonomous 3D printer vending machine.
- The team identified a 3D printer, the Reprap Prusa Mendel, that meets our design constraints
- The team designed an enclosure and a strategy to dispense parts autonomously.
- A prototype of the design is in development.
- The next phase of the project is to develop the software to integrate these designs and automate the process.

The team would like to thank the Clemson University Creative Inquiry program for funding the project.